Title: Multi-Model Ensemble Forecast of MJO

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Requested budget Year1: $172,171; Year2: $167,948; Year3: $172,499

Abstract

The Madden-Julian Oscillation (MJO) is the most prominent form of intraseasonal variability in the tropics and a primary source of predictability for sub-seasonal variations, including those in the subtropics and extra-tropics. This predictability extends to many aspects of low-frequency weather modulation, including high impact events such as hurricanes, as well as tropical-extratropical interactions that can lead to extreme precipitation events for example along the US west coast. Dynamical models have improved greatly in the past decade and a few models have produced rather credible simulations of the MJO, with evidence of useful prediction skill of the principal characteristics of the MJO out to a lead-time comparable to empirical-statistical schemes. Despite significant societal and environmental demands for accurate prediction of MJO and notable improvements in our ability to simulate the MJO, operational prediction of MJO and intraseasonal variability (ISV) is still in its infancy and its achievement seen as a great challenge faced by operational weather forecast centers.

The objective of the proposed research is to improve MJO prediction in CFS model and to develop a Multi-Model Ensemble (MME) methodology, based on coupled atmosphere and ocean models (CGCMs), for the operational prediction of the MJO and associated N. American impacts during boreal winter. In order to fulfill this objective, our proposed work consists of the following development tasks: I) Construct a well-designed and coordinated hindcast experiment using seven coupled global models. II) Use the hindcast experiment to assess the predictability and prediction skill of the MJO and related N. American impacts during boreal winter. III) Examine the prediction skill sensitivity to aspects of initialization as well as structural and parameterization differences within the multi-model hindcast. IV) Use the hindcast experiment to develop an MME technique suitable for MJO prediction and assess improvements in MJO

prediction skill. V) Combine the MME and the multi-model MJO forecast activity implemented at CPC in cooperation with the US CLIVAR MJO Working Group to deliver an MME forecast methodology suitable for implementation at National Center for Environmental Prediction (NCEP). VI) Using historical data combined with the multi-model hindcast, develop composite maps of the N. America weather/climate response to the life-cycle of the MJO.

This proposed research is an intimate collaboration of CPC and EMC scientists and a group of climate scientists having rich experience with MJO research, and builds on recent multi-institutional efforts at developing an MJO forecast system via US CLIVAR MJO Working Group activities, and its continuation as a WCRP/WWRP Task Force. Deliverables by this proposal to CTB include: A) A first-ever "community" multi-model hindcast data base – based on coupled models – suitable for MJO/intraseasonal predictions studies, including model intercomparison and improvement, prediction and predictability studies, and MME development. B) A tested methodology for combining dynamical forecasts to produce a MME forecast of the MJO and its impacts, including examination of skill sensitivity to initial conditions and other considerations. C) Composite maps of the N. America weather/climate response to the MJO, including dependence on MJO phase and statistical uncertainties.

Completion of this project will make a significant contribution to NOAA's goal in delivering cutting-edge extended range and seamless predictions to the Nation and global community.

1. Results from Prior Research

The modeling groups on this proposal have made great efforts on improving simulation and prediction of the MJO in recent years. The predictability and prediction of MJO have been intensively studied by UH investigators on this proposal with UH coupled model, which consists of the modified European Center-Hamburg Atmospheric Model (ECHAM) and a two and half layer tropical ocean model (Wang et al. 1995). The research has been focused on three critical processes for improving MJO forecast: air-sea coupling, shallow convection and downdraft, and stratiform clouds.

One of the weaknesses of the original ECHAM model, as in many others, is that the predicted MJO event propagates with a speed about 1/3 slower than observed as illustrated in **Fig. 1**. Why does the MJO propagation in the original model tend to be slow? Analysis of the model MJO structure against the NASA Aqua/AIRS observations (Fu and Wang 2004; Fu et al. 2006; Tian et al. 2006; and Yang et al. 2007) reveals that the model underestimates the moisture preconditioning ahead of convection and the dryness underneath the convection. Thus, the original ECHAM cumulus parameterization was revised by increasing shallow-convection detrainment and convective downdrafts. As a result, the model improved the MJO propagation significantly (Fu et al. 2008). One of the strength of the original ECHAM model lies in its adequate simulation of the ratio between stratiform and convective precipitation, which is critical for MJO prediction (Fu and Wang 2009).